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CONNECTOR AND CABLE ASSEMBLY SPECIFICATIONS FOR THE SHAPE FIBER OPTIC NETWORK

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The SHAPE Fiber Optic Network is a multiple-access-route ring-and-spoke communications system designed for survivability and restoration. In such a system, fiber optic connectors become a crucial component of the deployment philosophy because they provide the desired flexibility under both normal and emergency operations. Detailed specifications for monofiber and multiple-channel fiber optic connectors and cable connector assemblies are herein presented.

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PART I

CONNECTOR AND CABLE ASSEMBLY SPECIFICATIONS FOR THE SHAPE FIBER OPTIC NETWORK

1. INTRODUCTION

The SHAPE Fiber Optic Network is a multiple-access-route ring-and-spoke communications system designed for survivability and restoration. In such a system fiber optic connectors become a crucial component of the deployment philosophy since they provide the desired flexibility under both normal and emergency operations. Detailed specifications for monofiber and multiple-channel fiber optic connectors and cable connector assemblies are herein presented.

Part I of the specifications define, in general, the connector terminology, the system concepts and connector characteristics required for the implementation of the SHAPE ring- and-spoke network. Part II establishes the specifications for monofiber connectors. Multiple-channel fiber optic connector requirements and specifications are defined in part III. In part IV the specifications for a complete fiber optic cable connector assembly are summarized and the specific measurement procedures required to check out the total assembly are specified.

1.1 Scope. This specification package establishes the general requirements for the material, design, optical, mechanical, and environmental characteristics as well as the test and measurement procedures, qualification tests and quality assurance provisions pertinent to monofiber and multiple-channel fiber optic connectors. In addition, specifications for fiber optic cables and connector assemblies are presented.

1.2 Connector terminology and definitions. Two types of fiber optic cable connectors are specified in this document:

a) Monofiber connectors

b) Multiple-channel fiber optic connectors.

The multiple-channel fiber optic connectors are, in turn, defined according to their configuration characteristics as:

b1) Multichannel hermaphroditic fiber optic connectors

b2) Multichannel monofiber connector interface.

All three connector types are defined as follows:

A monofiber connector is defined as a device that optimally transfers optical power between two fibers, by providing an alignment of the fibers in a manner that permits repeated matings through a mechanical engagement. The connector housing must protect the fiber from the service environment and during handling in a manner that precludes the application of a mechanical load onto the fiber.

A multichannel hermaphroditic fiber optic connector is defined as a device that optimally transfers optical power between the termini of two multifiber cables through a single mechanical engagement, by providing a simultaneous optical alignment of all individual fibers in a manner that permits repeated matings between any set of connectors.

The concept of the multichannel monofiber connector interface is envisioned as a means of adopting the lower insertion loss and more mature technology of monofiber connectors in a design configuration that permits the interconnection of several optical fibers in a cable, on a one-to-one basis, within an enclosure.

The multiple-channel connectors shall be used in the system as part of a fiber optic cable connector assembly. A fiber optic cable connector assembly is defined as a fiber optic cable of a specified length, terminated by multiple-channel fiber optic connectors that permit the proper interconnection of the cable to other links in a communication system. The cable connector assemblies are stored on a tactically deployable, lightweight, impact resistant reel, when not in use.

1.3 System application of monofiber connectors. The SHAPE fiber optic ring-and-spoke network is broken up at Reconstitution Centers into individual link segments that are interconnected through the use of monofiber connectors. These connectors, under normal operational procedures, are part of a permanent fiber optic plant installation. They interface and provide access to corresponding parts of the network at optical patch panels, as shown in figure 1A. Any link in the network may be bypassed by an independent, field survivable fiber optic cable that is connected, as shown in figure 1B, through its own set of matching connectors to a reconstitution

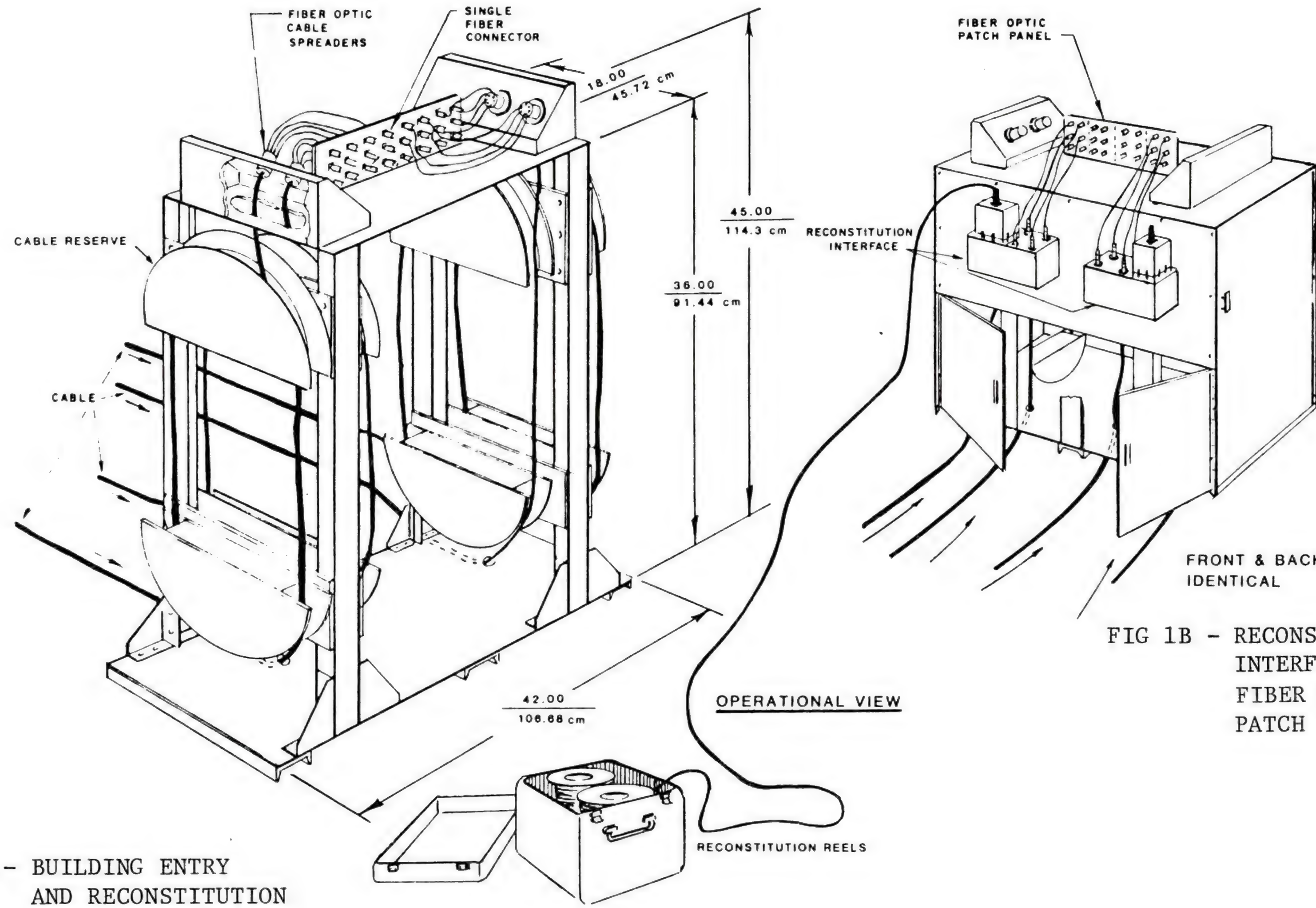

FIG 1A - BUILDING ENTRY AND RECONSTITUTION CENTER FIBER OPTIC PATCH PANEL

FIG 1B - RECONSTITUTION INTERFACE TO FIBER OPTIC PATCH PANEL

interface package. The reconstitution package consists of either a multichannel hermaphroditic fiber optic connector or a multichannel monofiber connector interface to link the fiber optic cable connector assembly into the network.

Monofiber connectors are thus used either on permanently installed patch panels located at Building Entry and Reconstitution Centers or within the enclosures of multichannel connector interfaces.

1.4 The multichannel monofiber connector interface concept. The multichannel monofiber connector interface concept is described to suggest a possible solution to the desired low insertion loss performance for a hermaphroditic multiple-channel fiber optic connector. Shown in figure 2A is a possible configuration for a multichannel monofiber connector interface. A prospective bidder shall propose a unit to meet the specifications detailed in part III and configure a design compatible to the specifications.

The multichannel monofiber connector interface has a backshell section that provides strain relief and environmental sealing for the multiple-fiber tight-bound cable and associated monofiber connectors. The individual fibers of the cable pass directly through a cable spreader, providing strain relief both to the cable and the buffered fibers. Individual fibers removed from their protective cable sheath and Kevlar are then provided with a separate protective sheath and terminated with monofiber connectors. The arrangement shown provides for the mating of a four-fiber cable. To eliminate any possible connection errors, the monofiber connectors are color-coded, with the same colors as used on the optical fiber buffer. The fibers within each backshell enclosure must be of a sufficient length to provide for ease of mating, before the two halves of the backshell are snapped together and firmly secured with drawbolts. A pin alignment at the interface of the backshell, shown in the detail of figure 2B, ensures accurate mating of each enclosure. A rubber gasket placed at the interface provides for water tightness and environmental isolation. After the drawbolts are secured, further mechanical rigidity against excessive tensile loads is obtained through a support bar that firmly attaches both halves of the backshells together. This support bar is shown in figure 2C. Each backshell, as shown in Figure 2D, must be secured with its own dust-cap cover. When mating the monofiber connectors in each backshell, provision must be made for snapping the covers onto the backshells or securing them in some similar manner, as shown in Figure 2E. The two backshells, which have been mated fiber to fiber through monofiber connectors, are shown assembled as one unit, in figures 2A and 2C.

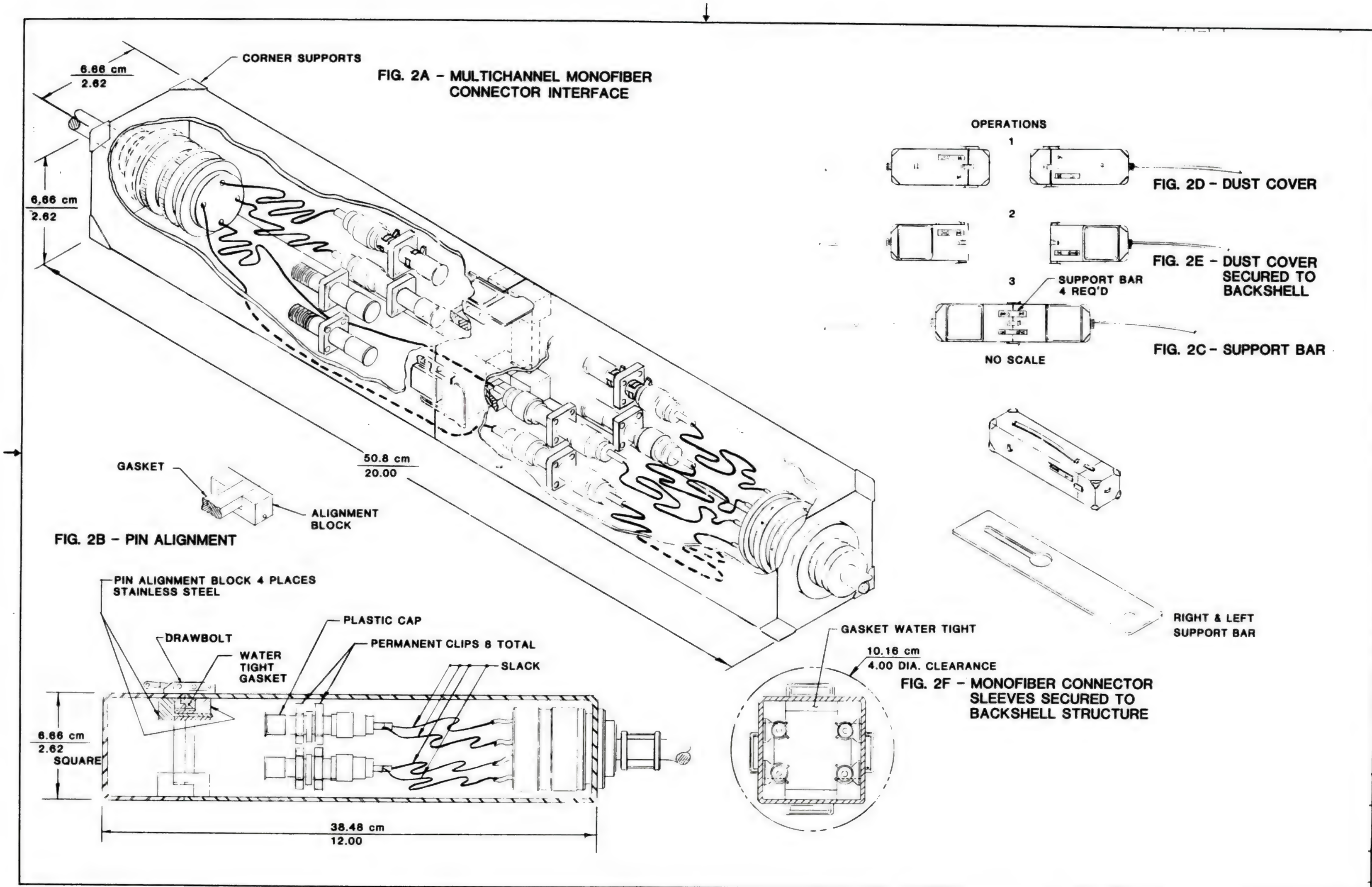

FIG. 2A - MULTICHANNEL MONOFIBER CONNECTOR INTERFACE

FIG. 2B - PIN ALIGNMENT

FIG. 2D - DUST COVER

FIG. 2E - DUST COVER SECURED TO BACKSHELL

FIG. 2C - SUPPORT BAR

FIG. 2F - MONOFIBER CONNECTOR SLEEVES SECURED TO BACKSHELL STRUCTURE

In figure 2A a pair of monofiber connectors are shown in a mated state within the backshell structure. To provide ease of monofiber connector mating outside the structure a sufficient reserve of single fiber cabling is provided. The monofiber connectors are shown in figure 2F, secured to the backshell enclosure, prior to snapping together the two halves of the interface. When not mated together each monofiber connector shall be protected with an individual dust-cap and secured in place as shown in figure 2A.

Monofiber connectors used in the multichannel monofiber connector interface shall meet the requirements of part II of this specification. A complete and mated multichannel monofiber connector interface shall meet all performance requirements of part III of this specification.

PART II

MONOFIBER CONNECTOR SPECIFICATION

1. INTRODUCTION

1.1 Scope. This section of the specification establishes detailed requirements for a monofiber connector to be used as a termination for the buried fiber optic cables, at Reconstitution Centers and Building Entry Terminals, throughout the Ring-and-Spoke Fiber Optic Communication System.

1.2 Connector terminology and definitions. Part I, 1.2 defines a monofiber connector and its generically desired characteristics.

1.3 Compliance. All requirements and test procedures cited in sections 2, 3, 4, 5, and 6 have been defined in conformity with the EIA FOTP-34, the IEC Subcommittee 46E Draft Proposals and the relevant Military Standards listed in 1.4. Any deviations from the test procedures cited or any other proposed test procedure shall be justified by the bidder. The contractor shall not be expected specifically to perform extensive tests on the monofiber connectors to establish performance of the connector with respect to the requirements of this specification. In lieu of testing, test results previously derived for monofiber connectors shall be supplied and shown to conform to the requirements of this specification.

1.4 Applicable documents. The following documents form a part of this specification.

EIA Draft Proposal FOTP-34 Working Group P6.4.1	"Interconnection Device Total Insertion Loss Test"
IEC Draft Proposal Subcommittee 46E Working Group 2	"Generic Specification for Connectors for Optical Fibers and Cables"
MIL-STD-1344A 1 September 1977	Test Methods for Electrical Connectors
EIA FOTP-36	Fiber Optic Test Procedures

MIL-STD-202F 1 April 1980	Test Methods for Electronic and Electrical Components
MIL-STD-810C	Environmental Test Methods for Electrical and Electronic Systems
Military Specification Sheet DoD-C-85045/1 10 November 1981	Cables, Fiber Optics, Type 1, Class 2, Composition A

2. MATERIAL AND DESIGN REQUIREMENTS

2.1 Materials. The materials used shall be lightweight, impact resistant, and of highest quality consistent with their application. They shall be fungus resistant, corrosion resistant, and selected to enable the connectors to meet all the performance requirements of this specification.

2.2 Dissimilar metals. If dissimilar metals are employed in contact with each other, provisions shall be made to provide suitable protection against electrolytic corrosion.

2.3 Nontoxic and nonhazardous. The connectors shall neither release toxic or explosive fumes nor support combustion when exposed to flame or chemical agents commonly used in the environment for which the connectors are designed.

2.4 Fluid resistant. The materials used in the environmental seals and other parts of the connector shall show no evidence of swelling or softening of material, loss of sealing capability, discoloration, or other effects detrimental to the proper operation of the connector when exposed to the following:

MIL-G-3056 - Gasoline

MIL-L-7808 - Lubricating oil, synthetic base

MIL-H-5605 - Hydraulic fluid, petroleum base

MIL-A-8243 - Ethylene glycol

2.5 Fungus resistant. Materials used in the construction of the connector shall be fungus inert under all conditions of humidity to which the connectors shall be exposed on a long term basis. (See humidity requirement 6.9.2.)

2.6 Environmental sealing. The mated connector assembly shall be environmentally sealed and shall comply with the requirements of section 5 of this specification.

2.7 Mating. Any connector of this design shall be capable of mating with another identical connector through a sleeve or bulkhead, to secure an established channel-to-channel connection.

2.8 Polarization. The connectors shall be mechanically polarized to assure a single proper mating orientation.

2.9 Dimensions. The exterior dimensions of the mated connector assemblies shall be in consonance with good commercial practice, allowing for ease of mating or disconnection. When installed on a standard 19-inch-wide (47.5 cm) equipment rack, at least eight such connectors shall be lined up and allow for ease of manipulation by an operator. The total length of a sleeve and two-plug assembly shall not exceed 4 inches (10 cm).

2.10 Cable and fiber compatibility. The connector shall be designed to accommodate a 50 $\pm$ 4 / 125 $\pm$ 4 / 500 $\pm$ 50 micrometer fiber. The connector shall interface with a fiber protective sheath that incorporates Kevlar strands to provide strain relief and tensile strength to the connector plug assembly. The prospective bidder shall specify whether the proposed connector accommodates a loose-bound or tight-bound fiber cable design configuration.

2.11 Protective cover. Each connector plug and connector sleeve shall have a protective dustcover, to provide mechanical and environmental protection, when not in use.

2.12 Handling. The connector shall be designed to withstand normal handling and usage commensurate with this application.

2.13 Designation. Mating connectors shall be color coded as per the six colors of the optical fiber cables. The color code designation shall be easily recognizable and nonerasable, to eliminate any cable mating errors.

3. OPTICAL REQUIREMENTS

3.1 Insertion loss

3.1.1 Definitions. The insertion loss shall be defined as the coupling loss between connectors that have been terminated in fibers. The coupling loss is comprised of both extrinsic and intrinsic loss mechanisms. Extrinsic losses of the connector are those associated

with fiber characteristics, such as Fresnel reflection loss, or fiber core size variations that contribute to the coupling loss. Intrinsic losses are connector hardware design dependent. For identically matched fibers within a connector assembly the intrinsic losses are due to the gap spacing, lateral and angular misalignment characteristics of the connectors.

3.1.2 Requirements. The maximum insertion loss per monofiber connector shall not exceed 0.5 $\pm$ 0.1 dB, at a wavelength of 1300 nm, including all intrinsic and extrinsic losses. Connector sleeves and plugs shall demonstrate the specified insertion loss when selected and connected to specified fiber cables at random.

The use of index matching fluid between connector plugs, to reduce the extrinsic insertion loss between connectors, shall only be allowed in the permanent plant application of the monofiber connectors. In this particular application repeated matings between connector pairs do not occur since the connector assembly shall be a part of a permanent plant installation. However, the application of the monofiber connectors in the multichannel connector interface, as specified in part III, shall preclude the use of index matching fluid in the field environment.

3.2 Optical continuity and distortion. No discontinuities or intermittent interruptions in signal power of duration greater than 25 nanoseconds and/or loss greater than 0.5 $\pm$ 0.1 dB shall be allowed during any of the mechanical or environmental tests that require optical power flow through the connector during the tests.

3.3 Ambient optical pick-up. The design of the connector shall preclude optical pickup from ambient light sources external to the mated connector pair.

4. MECHANICAL REQUIREMENTS

4.1 Coupling interface. A fully threaded interface or a bayonet-type coupling arrangement between a plug and its sleeve shall be provided. The engagement and disengagement of a connector plug from its sleeve or bulkhead shall not require excessive force and shall be easily performed.

4.2 Mating durability. The connector assembly shall be made to withstand repetitive matings as specified in 6.2 and comply, throughout such tests, with the insertion loss requirement of 3.1.

4.3 Flex. There shall be no mechanical failure or degradation of connector properties that may be detrimental to the operation of the connector when tested in accordance with 6.3. The insertion loss and optical continuity requirements of 3.1 and 3.2 shall be met throughout this test sequence.

4.4 Strain relief twist. There shall be no degradation of the strain relief mechanism or loosening of the connector seals or other connector damage that is detrimental to the performance of the connector when the strain relief mechanism is twist tested in accordance with 6.4. Optical continuity and insertion loss requirements of 3.2 and 3.1 shall be met during testing.

4.5 Tensile strength

4.5.1 Tensile strength of mated connector plug assembly. A mated connector pair and its sleeve assembly shall be subject to tensile strength testing to establish the integrity of the mating and to assess the effectiveness of plug captivation as specified in 6.5.1. The insertion loss of the connector shall meet the requirement specified in 3.1 during testing.

4.5.2 Cable pullout strength. The effectiveness of the connector plug fiber optic cable clamping device shall be assessed through the application of a tensile load, as specified in 6.5.2. During and after the test the connector shall meet the optical requirements for insertion loss and discontinuities as specified in 3.1 and 3.2.

4.5.3 Effectiveness of fiber captivation in connector plug termini. The reliability with which the individual fiber is inserted into the connector plug or any subsidiary terminal within the plug shall be certified per the test procedure outlined in 6.5.3. Any displacement of the fiber within the connector assembly shall not be allowed.

4.6 Vibration. There shall be no evidence of broken, loose, displaced, or damaged connector components or other defects which would preclude normal functioning of the connector assembly when it is vibration tested in accordance with 6.6. The connector shall be capable of meeting the insertion loss and optical continuity requirements of 3.1 and 3.2 during testing.

4.7 Shock. There shall be no evidence of damage that would affect normal functioning of the connector after being shock tested in accordance with 6.7. The connector shall be capable of meeting the insertion loss requirement of 3.1 after testing.

4.8 Impact. There shall be no evidence of damage that would affect normal functioning of the connector after being impact tested in accordance with 6.8. The connector shall be capable of meeting the insertion loss requirement of 3.1 after testing.

5. ENVIRONMENTAL REQUIREMENTS

5.1 Thermal. The connector shall comply with the insertion loss requirement of 3.1 during exposure to thermal shock as specified in 6.9.1.

5.2 Humidity. There shall be no evidence of moisture penetration of environmental seals after exposure to high humidity and temperature excursions as specified in 6.9.2. The connector shall be capable of meeting the insertion loss requirement of 3.1 during and after testing.

5.3 Submersion. There shall be no evidence of moisture penetration of environmental seals after water submersion as specified in 6.10. The connector shall be capable of meeting the insertion loss requirement of 3.1 during the test exposure.

6. TEST AND MEASUREMENT PROCEDURES

6.1 Insertion loss

6.1.1 Total insertion loss measurements. Insertion loss measurements shall be conducted in accordance with the EIA draft proposal FOTP-34/Working Group P6.4.1 document, "Interconnection Device Total Insertion Loss Test," or according to the IEC Technical Sub-Committee No. 46E, Working Group 2 Draft Publication on "Generic Specification for Connectors for Optical Fibers and Cables."

6.1.2 Extrinsic loss. The extrinsic loss of a mated connector assembly shall be measured in accordance with EIA FOTP-34, Method D or IEC Subcommittee 46E, Method 2. This procedure isolates the loss component due to fiber/cable parameters beyond the control of the connector design. A statistically valid sample size shall be used to establish the extrinsic insertion loss associated with the fiber type used for testing.

6.1.3 Intrinsic Loss. The intrinsic loss of the connector is defined as the total insertion loss measurement, as described in 6.1.1, minus the maximum extrinsic loss obtained in 6.1.2 as shown below.

Intrinsic loss (dB) = total insertion loss (dB) - maximum extrinsic loss (dB)

In any of the above the measurement of total connector insertion loss and connector extrinsic loss shall be compensated for source output power variations and for any mechanical or environmental effects that may influence the measurements. A sufficiently large statistical sample of measurements shall be obtained in the determination of the connector extrinsic losses due to the pertinent fiber characteristics.

6.2 Mating durability. The connector plugs shall be fully engaged and then disengaged from their common sleeve, in the manner prescribed by the manufacturer, a total of 100 times. At the termination of a 50-cycle mating each plug shall be cleaned and, if necessary, index matching fluid deposited on the tip of the termini, and the measurements repeated.

6.3 Flex. A rotation of $\pm 90^\circ$ shall be exerted from the initial position of the connector, very similar to Method 2017, Procedure 1, MIL-STD-1344A, for a total of 50 complete cycles. After this is completed, the connector shall be rotated 90° in the test fixture and the procedure repeated.

6.4 Strain relief twist. A mated connector assembly shall be twist-tested in accordance with EIA standard fiber optic test procedure FOTP-36. In this test procedure, a mated connector pair is held rigidly in a vertical orientation, with the cable from one connector half hanging downward. The cable is grasped at a distance equal to 10 times the cable diameter, from the back end of the connector. The cable is kept taut and the cable clamping fixture is rotated 90° in one direction, then back 180° in the opposite direction, then back to the starting position. This motion constitutes one cycle. Ten of these cycles shall be performed.

6.5 Tensile strength. The tensile strength tests shall be performed according to the IEC SubCommittee 46E, Working Group 2 draft specification for connectors as specified in 4.6.4, 4.6.5, 4.6.7, and 4.6.8. The following tests shall be performed and data presented:

6.5.1 Plug captivation and shearing static load test. The object of this test is to determine the suitability of a fixed connector for use in locations where it may be subject to tensile and shearing forces. The connector shall be rigidly mounted on a metal plate simulating the normal method of fixing the connector to the panel. A steady force of 100 newtons shall be applied to the connector in a direction perpendicular and then parallel to the mounting plane, at a rate of 5 newtons/second. The attenuation in the connector shall be measured after the applied forces have been removed.

6.5.2 Cable pulling test. The object of this test is to determine the effectiveness of the clamping device used to anchor the cable inside the connector against cable pulling. The maximum applied force shall be 200 newtons applied at a rate of 5 newtons/second. The attenuation in the connector shall be measured during and after the test.

6.5.3 Fiber captivation in the termini. With the appropriate fiber attached in accordance with the manufacturer's instructions, an axial force at a rate of 5 newtons/second shall be applied to reach 5 newtons in 5 seconds. No displacement of the fiber shall be allowed.

6.6 Vibration. A mated connector pair shall be subject to vibration as specified in MIL-STD-1344A, Method 2005.1, Test Condition IV or IEC Subcommittee 46E, Working Group 2 Draft Specification, 4.6.2 with a peak acceleration of 10 g's at frequencies ranging from 10 to 150 Hz. The frequency range of 10 to 150 Hz and return to 10 Hz shall be traversed in 20 minutes. This cycle is to be performed 12 times in each of 3 mutually perpendicular directions for a total of 36 cycles.

6.7 Shock. A mated connector pair shall be subjected to controlled pulse shock testing as specified in MIL-STD-1344A, Method 2004.1, Test Condition I or IEC Subcommittee 46E, Working Group 2 Draft Specification, 4.6.11. This procedure specifies a sawtooth pulse waveform of 11 milliseconds normal duration exerting a peak value of 30 g's on the connector. Three shocks in each direction shall be applied along the 3 mutually perpendicular axes of the connector for a total of 18 shocks.

6.8 Impact. A connector mated to its protective cover shall be subject to impact testing as specified in MIL-STD-1344A, Method 2015 using the moderate service class specification. This specification requires 1 drop at each of 8 radial orientations of the connector at heights of 120 and 240 cm for a total of 16 drops.

6.9 Climatic sequence tests. Climatic sequence tests of the connectors, consisting of thermal shock, humidity condensation, and freezing shall be carried out.

6.9.1 Thermal shock. A mated connector pair shall be subjected to the thermal shock test as specified in MIL-STD-202F, Method 107F, Test Condition A or IEC, SubCommittee 46E Draft Specification, 4.7.1 and 4.7.4 except that the low and high temperature extremes shall be $-15^{o}C$ and $55^{o}C$, respectively. Performance requirements are specified in 5.1.

6.9.2 Humidity. A mated connector pair shall be subjected to humidity testing as specified in MIL-STD-1344A, Method 1002.1, Type II or IEC, Subcommittee 46E Draft Specification, section 4.7.2. This requires temperature variations to occur in the presence of 80 to 98 percent relative humidity and a subfreezing exposure to occur at the end of the sequence. Performance requirements are specified in 5.2.

6.10 Submersion. A mated connector pair shall be immersed in water at a depth of two meters for a period of two hours. Performance requirements are specified in 5.3.

7. QUALIFICATION TESTS

7.1 Objective. Qualification tests determine if the design, construction, and materials used in the manufacture of the connectors comply with the requirements of this specification.

7.2 Testing. The bidder shall not be expected to prepare extensive qualification tests to demonstrate monofiber connector performance. The monofiber connectors to be proposed will already have been evaluated in conformity to the EIA FOT P-34 or IEC Subcommittee 46E draft proposals. Since the monofiber connectors specified herein are standard components that have been used in other fiber optic communication system applications, it is expected that the necessary statistical data in support of their performance is available. In case of the unavailability of data, the bidder shall be expected, during contract performance, to demonstrate conformity to the specifications by testing of a statistically meaningful sample size of connectors, chosen at random from the normal production.

7.3 Procedure. Performance of the monofiber connectors shall be shown to be subject to the tests cited in the material and design requirements section. The test procedures shall be as specified in the test and measurement procedures section of this specification. Any monofiber connector performance characteristic that has not been documented through prior testing, shall be demonstrated, during contract performance, to be in conformity with the specifications.

7.4 Test results. Test results, if presently available, shall be provided with the proposal.

8. SPECIAL MODIFICATION OF MONOFIBER CONNECTORS

8.1 Objective. A subset of monofiber connectors specified in the preceding sections shall be modified to provide for an interface with a microswitch when installed on a fiber optic patch panel.

8.2 Extent of modification. A collar, as shown in figure 3, shall be added to the connector. When interfacing with the sleeve, the extended connector plug shall provide a firm point of contact with a microswitch positioned behind a fiber optic patch panel. The collar shall be permanently secured onto the plug. The dimensions of the collar, for a prototype connector, and the location of the micro-switch are shown in figure 3. The connector plug shall be extended with a collar, 44 mm in diameter, in order to interface with a model number 37XL11XA-22 switch, manufactured by Microswitch, a division of Honeywell Corporation, or its equivalent.

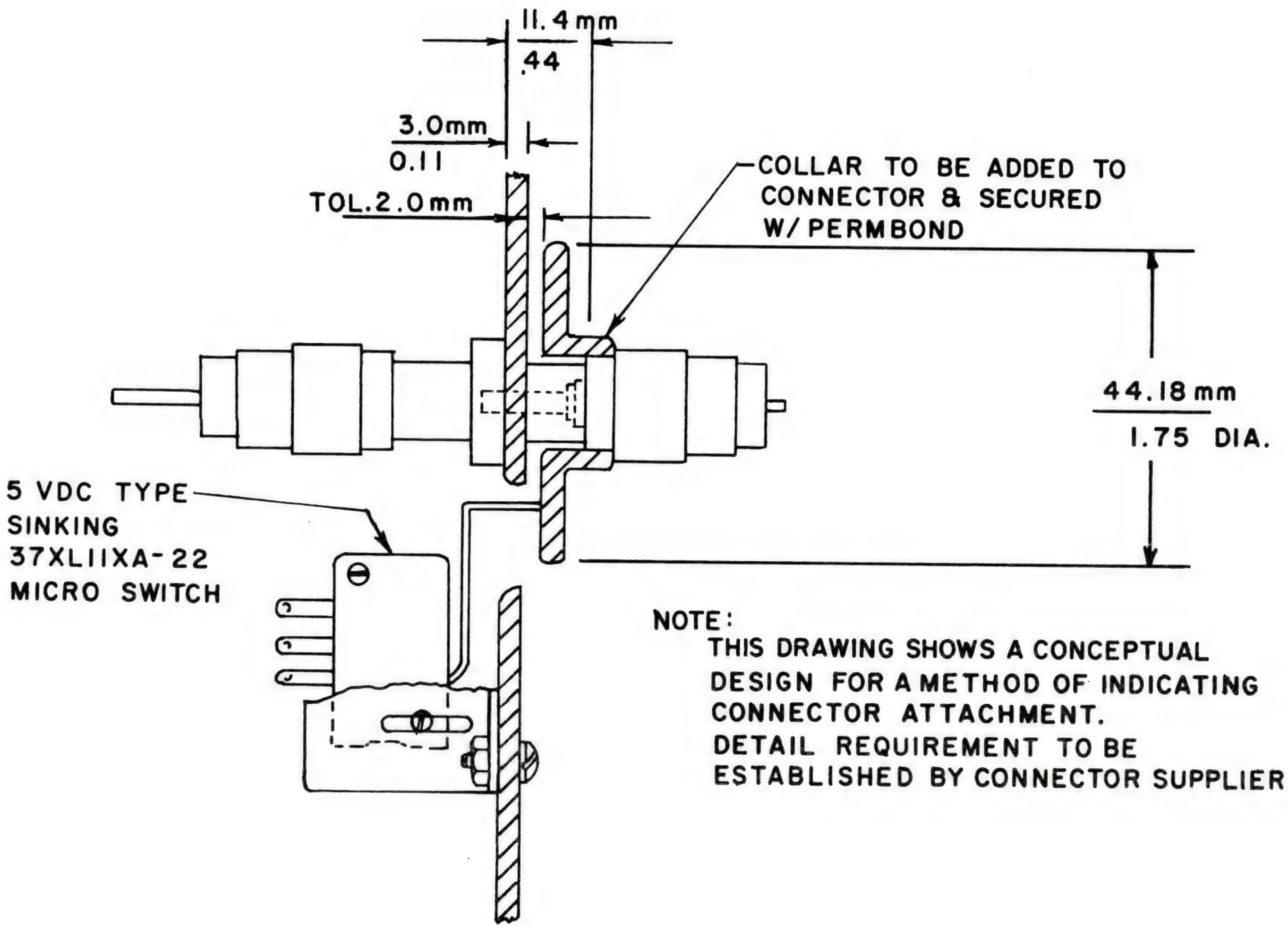

Figure 3. Fiber Optic Connector Interface at Microswitch.

PART III

MULTIPLE-CHANNEL FIBER OPTIC
CONNECTOR SPECIFICATION

1. INTRODUCTION

1.1 Scope. This section of the specification establishes the detail requirements for a multiple-channel fiber optic connector to be used as an integral part of the fiber optic cable assemblies specified in this document. The specifications address the required characteristics of the multichannel hermaphroditic fiber optic connector and the multichannel monofiber connector interface, as defined in Part I.

1.2 Connector terminology and definitions. Part I, 1.2 defines a multichannel hermaphroditic fiber optic connector and a multichannel monofiber connector interface and their generically desired characteristics.

The term multiple-channel fiber optic connector as used in this specification shall refer to both types of configurations.

1.3 Compliance. All requirements and test procedures cited in sections 2, 3, 4, 5 and 6 have been defined in conformity with the EIA FOTP-34, the IEC Subcommittee 46E Draft Proposals and the relevant Military Standards listed in 1.4, Part II. Any deviations from the test procedures cited or any other proposed test procedure shall be justified by the bidder. Test results previously derived for the multichannel hermaphroditic fiber optic connector by the manufacturer shall be supplied with the proposal and shown to conform to the requirements of this specification. If a multichannel monofiber connector interface is specifically designed, or an existing tested design is altered to meet this specification, the connector must undergo qualification tests as specified in 7.

1.4 Applicable Documents. Refer to 1.4 of part II for a complete listing of applicable documents.

2. MATERIAL AND DESIGN REQUIREMENTS

2.1 Materials. The materials used shall be lightweight, impact resistant, and of highest quality consistent with their application. They shall be fungus resistant, corrosion resistant, and

selected to enable the connectors to meet all the performance requirements of this specification.

2.2 Dissimilar metals. If dissimilar metals are employed in contact with each other, provisions shall be made to provide suitable protection against electrolytic corrosion.

2.3 Nontoxic and nonhazardous. The connectors shall neither release toxic or explosive fumes nor support combustion when exposed to flame or chemical agents commonly used in the environment for which the connectors are designed.

2.4 Fluid resistant. The materials used in the environmental seals and other parts of the connector shall show no evidence of swelling or softening of material, loss of sealing capability, discoloration, or other effects detrimental to the proper operation of the connector when exposed to the following:

MIL-G-3056 - Gasoline

MIL-L-7808 - Lubricating oil, synthetic base

MIL-H-5605 - Hydraulic fluid, petroleum base

MIL-A-8243 - Ethylene glycol

2.5 Fungus Resistant. Materials used in the construction of the connector shall be fungus inert under all conditions of humidity to which the connectors shall be exposed on a long term basis. (See humidity requirement 6.11.)

2.6 Environmental sealing. The mated connector assembly shall be environmentally sealed and shall comply with the requirements of section 5 of this specification.

2.7 Hermaphrodicity. The connectors shall be hermaphroditic such that any connector of this design shall be capable of mating with another identical connector to secure an established channel-to-channel connection.

2.8 Polarization. The connectors shall be mechanically polarized to assure a single proper mating orientation.

2.9 Protective cover. The connector shall have a captive protective dustcover to provide mechanical and environmental protection, when not in use.

2.10 Dimensions. The multichannel hermaphroditic fiber optic connector shall conform to individual manufacturer specifications relative to size. The conceptual design of a multichannel monofiber connector interface, as shown in figure 2A of Part I, requires a mated connector assembly length not greater than 50 cm and a width of 6.7 cm. However, the prospective bidder shall propose a configuration for the multichannel monofiber connector interface relative to his own design philosophy. Thus either a cylindrical or rectangular configuration shall be acceptable. The mated multiple-channel fiber optic connectors, in all cases, shall conform to a width that can, with ease, be inserted through a 10 cm diameter access hole.

2.11 Weight. Mated pairs of the multichannel monofiber connector interface shall not weigh more than 1 kilogram, including their protective covers. The weight of the multichannel hermaphroditic fiber optic connector shall conform to individual manufacturer specifications, usually of the order of one-half of a kilogram.

2.12 Cable and fiber compatibility. The connector fiber termini shall be designed to accommodate a buffered fiber of dimensions 50 ± 4 / 125 ± 4 / 500 ± 50 micrometers and the connector shall interface with a standard tight-bound four-fiber cable of 6.0 ± 0.5 millimeters outside diameter.

2.13 Handling. The connector shall be designed to withstand normal handling and usage commensurate with this application.

3. OPTICAL REQUIREMENTS

3.1 Insertion loss. The maximum insertion loss per channel of the connector shall not exceed 1.5 dB, with preference given to a maximum insertion loss of 1 dB or lower. The insertion loss is defined (see section 3, part II) to consist of both intrinsic connector and associated extrinsic fiber losses.

3.2 Optical continuity. For tests specifying optical continuity during the test exposure, signal intermittency shall not exceed 25 nanoseconds.

3.3 Optical crosstalk. The design of the connector shall preclude optical crosstalk from adjacent channels.

3.4 Ambient optical pickup. The design of the connector shall preclude optical pickup from ambient light sources external to the mated connector pair.

4. MECHANICAL REQUIREMENTS

4.1 Coupling forces

4.1.1 Engagement/disengagement. The engagement and disengagement of a connector pair shall not require excessive force and shall be easily performed by field personnel.

4.1.2 Coupling torque. The torque required to mate or unmate a connector pair shall not be excessive. Connector mating shall be easily performed by field personnel. Additionally the uncoupling torque must be large enough that the connector pair cannot be accidentally loosened by mechanical effects such as outlined in section 5.

4.2 Mating durability. The connector assembly shall be made to withstand repetitive matings as specified in 6.2 and still comply with the insertion loss requirements of 3.1.

4.3 Flex. There shall be no mechanical failure or degradation of connector properties that would be detrimental to the operation of the connector when tested in accordance with 6.3. The insertion loss and optical continuity requirements of 3.1 and 3.2 respectively shall be met throughout the test sequence.

4.4 Strain relief twist. There shall be no degradation of the strain relief mechanism or loosening of the connector seals or other connector damage that is detrimental to the performance of the connector when the strain relief mechanism is twist tested in accordance with 6.4. Optical continuity and insertion loss requirements of 3.2 and 3.1 shall be met during testing.

4.5 Tensile strength. The connector pair shall be subjected to tensile strength testing as specified in 6.5. The insertion loss of the connector shall meet the requirement specified in 3.1 during testing.

4.6 Vibration. There shall be no evidence of broken, loose, displaced, or damaged connector components or other defects that can preclude normal functioning of the connector assembly when it is vibration tested in accordance with 6.6. The connector shall be capable of meeting the insertion loss and optical continuity requirements of 3.1 and 3.2 during testing.

4.7 Shock. There shall be no evidence of broken, loose, displaced, or damaged connector components or other defects that can preclude normal functioning of the connector when it is shock tested

in accordance with 6.7. The connector shall be capable of meeting the insertion loss and optical continuity requirements of 3.1 and 3.2 during testing.

4.8 Impact. There shall be no evidence of damage that can affect normal functioning of the connector after being impact tested in accordance with 6.8. The connector shall be capable of meeting the insertion loss requirement of 3.1 after testing.

4.9 Crush. There shall be no broken seals or parts, evidence of inability to properly mate or unmate the connector, or other damage that can prevent proper operation of the connector when exposed to compressive loads as specified in 6.9. The connector shall be capable of meeting the insertion loss requirements of paragraph 3.1 after testing.

5. ENVIRONMENTAL REQUIREMENTS

5.1 Thermal. The connector shall comply with the insertion loss requirement of 3.1 during exposure to thermal shock as specified in 6.10.

5.2 Humidity. There shall be no evidence of moisture penetration of environmental seals after exposure to high humidity and temperature excursions as specified in 6.11. The connector shall be capable of meeting the insertion loss requirement of 3.1 during and after testing.

5.3 Submersion. There shall be no evidence of moisture penetration of environmental seals after water submersion as specified in 6.12. The connector shall be capable of meeting the insertion loss requirement of 3.1 during the test exposure.

5.4 Sand and dust. The mated connector pair shall meet the insertion loss requirement of 3.1 when exposed to sand and dust as specified in 6.13. After the exposure the connector must be capable of being cleaned, in accordance with the manufacturer's field cleaning procedures, remated and still comply with the insertion loss requirement.

6. TEST AND MEASUREMENT PROCEDURES

6.1 Insertion Loss

6.1.1 Total insertion loss measurements. Insertion loss measurements shall be conducted in accordance with the EIA draft

proposal FOTP-34/Working Group P6.4.1 document, "Interconnection Device Total Insertion Loss Test" or according to the IEC Technical Subcommittee No. 46E, Working Group 2 Draft Publication, "Generic Specification for Connectors for Optical Fibers and Cables."

6.1.2 Extrinsic loss. The extrinsic loss of a mated connector assembly shall be measured in accordance with the EIA FOTP-34, Method D or IEC SubCommittee 46E, Method 2. This procedure isolates the loss component due to fiber/cable parameters beyond the control of the connector design. A statistically valid sample size shall be used to establish the extrinsic insertion loss associated with the fiber type used for testing.

6.1.3 Intrinsic loss. The intrinsic loss of the connector is defined as the total insertion loss measurement as described in 6.1.1 minus the maximum extrinsic loss obtained in 6.1.2 as shown below.

Intrinsic loss (dB) = total insertion loss (dB) - maximum extrinsic loss (dB)

In any of the above the measurement of total connector insertion loss and connector extrinsic loss shall be compensated for source output power variations and for any mechanical or environmental effects that may influence the measurements. A sufficiently large statistical sample of measurements shall be obtained in the determination of the connector extrinsic losses due to the pertinent fiber characteristics.

6.2 Mating durability. The connector pair shall be fully mated, in the manner prescribed by the manufacturer, 200 times.

6.3 Flex. The mated connector pair shall be subjected to cable seal flexing per MIL-STD-1344A, Method 2017, Procedure 1. This procedure specifies flexing of the strain relief mechanism in a plane over a 180° arc, 90° in each direction from the normal, for a total of 100 complete cycles. After this is completed, the connector is rotated in the test fixture 90° and the procedure is repeated.

6.4 Strain relief twist. A mated connector assembly shall be twist-tested in accordance with EIA standard fiber optic test procedure FOTP-36. In this test procedure a mated connector pair is held rigidly in a vertical orientation with the cable from one connector half, hanging downward. The cable is grasped at a distance 10 times the cable diameter, from the back end of the connector. Weight is applied to the cable to keep it taught. The cable clamping fixture is rotated 90° in one direction, then back 180° in the opposite direction, then back to the starting position. This motion constitutes one cycle. Ten of these cycles shall be performed.

6.5 Tensile strength. A mated connector pair shall be tested in accordance with Method 2009.1, as specified in MIL-STD-1344A. The tensile load shall be applied so as to test the integrity of the mated pair's coupling mechanism and their strain relief members at the fiber optic cable. The test load shall equal 1000 newtons, applied in increments of 100 newtons, and held for a time duration of 1 minute.

6.6 Vibration. A mated connector pair shall be subject to vibration as specified in MIL-STD-1344A, Method 2005.1, Test Condition II with a peak acceleration of 10 g's at frequencies ranging from 10 to 500 Hz. The frequency range of 10 to 500 Hz and return to 10 Hz shall be traversed in 20 minutes. This cycle is to be performed 12 times in each of 3 mutually perpendicular directions for a total of 36 cycles.

6.7 Shock. A mated connector pair shall be subject to a controlled pulse shock testing as specified in MIL-STD-1344A, Method 2004.1, Test Condition I. This procedure specifies a sawtooth pulse waveform of 11 milliseconds normal duration exerting a peak value of 30 g's on the connector. Three shocks in each direction shall be applied along the 3 mutually perpendicular axes of the connector for a total of 18 shocks.

6.8 Impact. A connector mated to its protective cover shall be subject to impact testing as specified in MIL-STD-1344A, Method 2015 using the moderate service class specification. This specification requires one drop at each of eight radial orientations of the connector at heights of 120 cm and 240 cm for a total of 16 drops.

6.9 Crush. A mated connector pair shall be subject to compressive loading using the test procedure specified in MIL-STD-1344A, Method 2008.1. The load shall be 2500 newtons applied for 5 to 10 seconds. The load shall be applied in a direction perpendicular to the longitudinal axis of the connector and cable.

6.10 Thermal shock. A mated connector pair shall be subject to the thermal shock test as specified in MIL-STD-202F, Method 107F, Test Condition A. The low and high temperature extremes shall be -15°C and 55°C respectively. At the low and high temperatures the connector shall be held for 120 minutes prior to returning it to 25°C. Performance requirements are specified in 5.1.

6.11 Humidity. A mated connector pair shall be subject to humidity testing as specified in MIL-STD-1344A, Method 1002.1, Type II. This requires temperature variations to occur in the presence of

80 to 98 percent relative humidity and a subfreezing exposure to occur at the end of the sequence. Performance requirements are specified in 5.2.

6.12 Submersion. A mated connector pair shall be immersed in water at a depth of two meters for two hours. Performance requirements are specified in 5.3.

6.13 Sand and dust. A mated connector pair shall be subject to a dust test as specified in MIL-STD-810C, Method 510.1, Procedure 1, which specifies exposure to fine sand and dust with controlled temperature, humidity, and air velocity. Performance requirements are specified in 5.4.

7. QUALIFICATION TESTS

7.1 Objective. Qualification tests determine if the design, construction, and materials used in the manufacture of the connectors comply with the requirements of this specification.

7.2 Testing. Manufacturers of multichannel hermaphroditic fiber optic connectors shall provide test data with the proposal in conformity with the cited MIL-STD specifications. If any such data is not available the bidder shall demonstrate, during the contract phase, conformity to the specifications by testing of a statistically meaningful sample of connectors, chosen at random from the normal production.

The multichannel monofiber connector interface is an adaptation of the low insertion loss and more mature technology of monofiber connectors in a design configuration that permits the interconnection of four optical fibers in a cable, on a one-to-one basis, within an enclosure. The monofiber connectors within the enclosure backshell and the complete multichannel connector interface shall be subject to the specifications outlined in Part II and Part III, respectively. This concept shall be demonstrated by a bidder, during the contract phase, with prototype samples. The bidder shall propose a test program and schedule for the evaluation of the multichannel monofiber connector interface, subject to all the specified test conditions.

7.3 Procedure. Performance of the multiple-channel fiber optic connectors shall be shown to be subject to the tests cited in the material and design requirements section. The test procedures shall be as specified in the test and measurement procedures section of this specification. Any connector performance characteristic that

has not been documented through prior testing, shall be, during contract performance, demonstrated to be in conformity with the specifications.

7.4 <u>Test results</u>. Test results, if presently available, shall be provided with the proposal.

PART IV

SPECIFICATIONS FOR A FIBER OPTIC CABLE CONNECTOR ASSEMBLY

1. INTRODUCTION

1.1 Scope. This specification establishes the detail requirements for a fiber optic cable connector assembly that shall be deployed in the field, in support of the ring-and-spoke communications network.

1.2 Connector terminology and definitions. Part I, 1.2 defines a fiber optic cable connector assembly and its desired characteristics.

1.3 Compliance. The connectors used on the fiber optic cable connector assembly are subject to the requirements and performance characteristics detailed in parts II and III of this specification. The fiber optic cable used in the cable connector assembly is of the tight-bound design, fabricated to withstand field deployment conditions.

Individual connectors and fiber optic cables used in the cable connector assembly are required to demonstrate all specified performance, mechanical, thermal and environmental characteristics. The purpose of this specification is to establish requirements for a complete fiber optic cable connector assembly. The contractor shall be expected to measure and demonstrate all required performance tests to be specified in this section.

1.4 Applicable documents. Reference is made to all aforementioned documents, listed in 1.4 of part II.

2. FIBER OPTIC CABLE CONNECTOR ASSEMBLY REQUIREMENTS

2.1 Connectors. Connectors, as specified in part III of this specification, shall be used in the fiber optic cable connector assembly.

2.2 Fiber optic cable. A tactically deployable fiber optic cable shall be used. The cable shall consist of four fibers, of similar characteristics as those presently deployed in the ring-and-

spoke fiber optic cable plant installation. Technical information relevant to the characteristics of the fibers may be obtained from the Service General des Constructions, K.G.C./K.T.E., Ministry of Defense, Belgium. The fiber assembly shall be of a tight-bound design, reinforced with Kevlar strands and other strength members. The fiber optic cable shall comply with all the specified requirements for a four-fiber cable defined in the Military Specification Sheet, DoD-C-85045/1, dated 10 November 1981. The length of each fiber optic cable shall be 1500 meters.

2.3 Connector cable assembly. Connectors shall be installed at both ends of the 1500-meter cable, for a complete fiber optic cable connector assembly. This assembly shall be wound on an impact resistant, lightweight reel.

2.4 Reel. The reel shall be lightweight, of the order of 10 kg, and shall be made of impact resistant plastic material. It shall interface with a standard size winding mechanism and mechanical support structure that can be deployed manually or from a van.

The reel shall be designed to accommodate with ease 1500 meters of the optical fiber cable, together with the selected multiple-channel connectors. Provision shall be made at the reel that five meters of the buried end of the cable assembly, shall be available on a subsidiary drum. This drum shall be an integral part of the reel. Provision shall also be made at the reel to securely attach both ends of the connector assemblies and their protective covers, when not in use. The reel shall not be damaged and shall be reusable when the entire fiber optic cable connector assembly is unwound from it.

3. INSERTION LOSS MEASUREMENTS OF FIBER OPTIC CABLE CONNECTOR ASSEMBLY

3.1 Insertion loss. The insertion loss of a complete fiber optic cable connector assembly shall be measured by nondestructive means per IEC Subcommittee 46E, Working Group 2 Draft Specification, Method 6, outlined in 4.5.1.2.2.

In this method a standard reference power level is established when two halves of two reference hermaphroditic connectors are joined together. The reference connectors are then disconnected, and the cable connector assembly to be tested is inserted and joined to the reference connectors. The resultant power level is recorded at the receiver, and appropriate corrections are made for any source power level variations. The total connector cable assembly loss is then given by the ratio of the power levels, in decibels.

The insertion loss to be measured by the specified method on all four fibers and individual connectors shall represent the total loss due to 1500 meters of fiber and the two connector halves. The insertion loss for a 1500-meter <u>fiber optic cable connector assembly</u>, measured at 1.3 micrometers, shall not be greater than the sum total of the fiber optic cable loss and one hermaphroditic connector loss. As such at 1.3 micrometers, under normal operating conditions, the insertion loss, as measured, shall not be greater than 3.25 decibels.

3.2 <u>Insertion loss measurements under climatic conditions</u>. The <u>connector cable assembly</u> shall be subject to the thermal cycling tests specified in parts II and III of this specification. Any incremental change in the above specified insertion loss shall have to be accounted for relative to the individual environmental performance characteristics of the connectors and fiber optic cable.